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October, 1916

Bulletin No. 167

# Rotation and Manure Experiments on the Wisconsin Drift Soil Area

AGRICULTURAL EXPERIMENT STATION  
IOWA STATE COLLEGE OF AGRICULTURE  
AND MECHANIC ARTS

Agromony Section

Soils



Ames, Iowa

### SUMMARY

As a whole, these experiments on the Carrington loam show that:

1. The continuous growing of crops decreases the fertility of the soil and leads to rapidly declining crop yields.

2. The rotation of crops gives greater profit than the continued growth of corn.

3. A three-year rotation of corn, oats, and clover is more profitable than a two-year rotation of corn and oats, or a two-year rotation with clover, cowpeas, or rye used as a green manure crop.

4. The introduction of clover, cowpeas and rye into a two-year rotation increases the crop yields, but it can hardly be considered profitable except in the case of the clover. The profit is less, however, in every case than in the three year rotation.

5. The best amount of manure to apply to this type of soil appears to be between 8 and 16 tons per acre, applied once in a four-year rotation.

6. Applications of more than 16 tons of manure per acre are not profitable.

7. Manure applied in three equal amounts in the first, second, and fourth years of the four-year rotation prove of greater value on this soil than the same total amount applied once in the rotation.

8. Manure should not be applied to this soil after the corn crop is up, as very much smaller effects are secured from its use than when it is plowed under or disced in after plowing. On this soil type the latter method seems to be slightly preferable.

## ROTATION AND MANURE EXPERIMENTS ON THE WISCONSIN DRIFT SOIL AREA

BY W. H. STEVENSON AND P. E. BROWN

The rotation of crops and the use of manure have frequently been shown to be important in maintaining soil fertility. Their value is again emphasized by the results of experiments conducted by the agronomy section of the Iowa Agricultural Experiment Station at Ames, on the Carrington loam, the principal soil type of the Wisconsin drift area.

These results show clearly that rotation is not only beneficial to the soil, but that it brings more profitable yields as well, if the rotation be suited to the particular soil. They show, too, that the use of manure increases crop yields, but also that it must be applied in the right amounts, at the right time and in the right way, for some methods of applying are better than others.

Altho these facts are quite generally understood, too often the large profit which may be secured from some one crop induces farmers to grow that crop continuously on the same soil, regardless of the depletion of soil fertility which is bound to follow. Likewise, there is still much waste in the methods used in storing manure and applying it to the soil, even tho its great value as one of the most important farm products is commonly recognized.

The rotation and manure experiments reported in this bulletin were carried out at Ames on plots located on the Carrington loam of the main soil type of the Wisconsin drift.<sup>1</sup> The results secured are specific, therefore, for this particular soil type, and they amplify the conclusions presented in a previous report of fertility studies on this soil.<sup>2</sup> However, the principles involved may be applied generally and the teachings of these particular experiments may be made to fit quite diverse soil conditions.

The reasons for the effects of continuous cropping and different rotations are varied and largely theoretical and they are not considered in this bulletin, but actual crop yields are compared and the results are quite conclusive.

Unfortunately the land on which the experiment plots were lo-

<sup>1</sup> The Wisconsin drift area is found in the north central part of the state and covers in whole or in part the counties of Lyon, Osceola, Dickinson, Emmett, Kossuth, Winnebago, O'Brien, Clay, Palo Alto, Hancock, Buena Vista, Pocahontas, Humboldt, Wright, Sac, Calhoun, Webster, Hamilton, Carroll, Greene, Boone, Story, Marshall, Guthrie, Dallas, Polk, Hardin, and Jasper. It is of glacial origin and consists of the mass of material finally left behind when the ice disappeared. The Carrington loam is a dark brown to black mellow loam, containing a high percentage of organic matter. The content of silt, fine sand and sand is sufficiently high to make the soil crumbly and quite free from any tendency to become sticky, even when wet. It covers by far the largest part of the Wisconsin drift soil area.

<sup>2</sup> Bull. Iowa Agr. Exp. Sta. 161.



cated was needed by Iowa State College for other purposes and the work here reported was discontinued before it had been carried on as long as desirable. However, the results for the six years of the work are valuable. While a longer continuance of the experiments might have led to some variations in results, yet it is felt that the shorter tests fairly indicate what the results of longer tests would have been. Furthermore, they are in accord with general farm experience along the same line. More rotation and manure experiments are being conducted now on the new agronomy farm, but their results will not be available for some years. Moreover, the new experiments are on a different type of soil of the Wisconsin drift. Because of this reason, as well as for the reason that the results already secured are fairly conclusive, the report of the experiments is now presented.

### THE ROTATION EXPERIMENTS

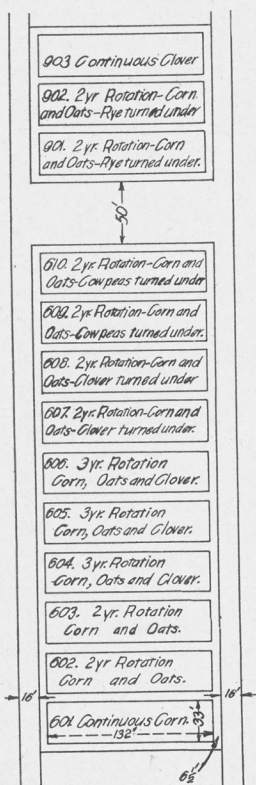


FIG. 1. Rotation experiment, 1-10 acre plots

The rotation experiments were carried out on 13 plots, each  $\frac{1}{10}$  of an acre in size, located on Carrington loam which is rather well supplied with plant food and comparatively rich in organic matter, making it, therefore, an excellent soil on which to test the relative effects of continuous cropping and of the rotation of crops. The land was fairly uniform in topography, the slope being toward the south, and was well drained. The effects of manure on such a soil, if any are secured, should also be considered quite conclusive.

The plan of the experiments is shown in fig. 1. The plots were 2 rods wide by 8 rods long and were separated by a  $6\frac{1}{2}$  foot division strip. The entire series was also surrounded by a cropped border  $6\frac{1}{2}$  feet wide.

Rotations were as follows:

Continuous corn.

2-year rotation, corn and oats.

3-year rotation, corn, oats, and clover.

2-year rotation, corn and oats, clover turned under.

2-year rotation, corn and oats, cowpeas turned under.

2-year rotation, corn and oats, rye turned under.

Continuous clover.

There were as many plots in each group as there were crops, three plots in the three-year rotation, two in each of the two-year rotations, and one plot each for the continuous corn and continuous clover. Thus each crop was grown each year under the varying seasonal conditions.

These plots were laid out in 1907 and the first crops were secured in 1908. The experiments were carried on until 1913 when the plots were given up; hence the results are for six years.

The method of handling the plots was the same as is employed in all plot work, the seeding, cultivating, and harvesting being done by machinery. All precautions were observed that the plots be treated as uniformly as possible to eliminate any possibility of questioning the results because of differences in treatment.

Thruout the experiment all the regular crops were removed from the land except the corn stalks, which were plowed under. The crops on the borders and division strips were removed in every case before the plots were harvested.

Twice during the six years the clover crop on the three-year rotation series of plots failed and cowpeas were sown. The yield of this crop was not secured. Hence the average yield for the clover in the three-year rotation was secured on the basis of four crops rather than six, while the corn and oats yields given are each the average of six crops. The average yields on the two-year rotation plots are all based on six crops. The continuous clover plot was not harvested in 1908 so that the average yield for that plot is based on five crops rather than six.

The clover turned under in the two-year rotation was seeded with oats, while the cowpeas and rye were seeded following the oats. In each case, the green manure crop was plowed under in the fall preceding the corn. In most cases the growth of the crops was satisfactory and a considerable amount of green material was thus turned under. Much larger amounts of green matter were added to the soil in the case of the rye, however, than with the clover or cowpeas.

The average yields and their value and the total value of the average yields of the various crops for the six-year period are recorded in table I. In making these calculations the corn was figured at 45 cents per bushel, the oats at 35 cents per bushel, and the clover at \$8.00 per ton. The total value of the average yields was determined on the basis of six crops on the continuous plots, three crops each of corn and of oats on the two-year rotation plots, and two crops each of corn, oats, and clover on the three-year rotation plots.

#### THE RESULTS

Considering the results given in the table, the average yield of corn on the continuous corn plot was very much less than on any

TABLE I. AVERAGE YIELDS AND TOTAL VALUE OF AVERAGE YIELDS OF CROPS IN VARIOUS ROTATIONS FOR SIX YEARS (1908-1913)

Treatment	Corn Bu.	Value \$	Oats Bu.	Value \$	Clover Tons	Value \$	Total Value All Av- erage Crops
Continuous Corn .....	40.32	108.84	.....	.....	.....	.....	108.84
2-Year Rotation — Corn and Oats .....	55.75	75.24	51.51	54.06	.....	.....	129.30
3-Year Rotation — Corn, Oats and Clover .....	64.25	57.82	65.14	45.58	2.97	47.52	150.92
2-Year Rotation — Corn and Oats, Clover turned under..	66.55	89.82	54.58	57.30	.....	.....	147.12
2-Year Rotation — Corn and Oats, Cowpeas turned under	55.18	74.49	54.81	57.54	.....	.....	132.03
2-Year Rotation — Corn and Oats, Rye turned under....	54.59	73.68	55.38	58.14	.....	.....	131.82
Continuous Clover .....	.....	.....	.....	.....	1.69	81.12	81.12

of the rotation plots. The largest yield of corn was given by the two-year rotation with clover turned under, while that in the three-year rotation was only slightly smaller. The average yields of corn under the other rotations were practically identical.

Examining the results for oats, it is found that the smallest average yield was secured in the unmodified two-year rotation and the yield in the three-year rotation was greater by about 14 bushels. The yields of oats on the modified two-year rotation plots were practically the same, being all slightly larger than those on the unmodified two-year rotation plots but considerably less than that on the three-year rotation plots.

The clover yield on the three-year rotation plots was considerably larger than that on the continuous clover plot. No one crop on the continuous clover plot was as large as the average yield in the three-year rotation.

The total value of all average crops in the various rotations for the six-year period, as given in the last column of table I, shows that the crops secured in the three-year rotation of corn, oats, and clover were of more value than those in any of the other rotations. The continuous corn and the continuous clover plots gave a much smaller value than any of the rotation plots and the use of clover, cowpeas, or rye in the two-year rotation increased the value of the crops of corn and of oats to a considerable extent in the case of the clover and slightly with the other crops. These total values of the crops are shown graphically in fig. 2.

It is apparent from these results that the continuous growing of corn or of clover is much less profitable than the use of rotations, and that a three-year rotation of corn, oats, and clover is much more valuable than a two-year rotation of corn and oats. This is true even altho it is commonly believed that corn is the money crop and should be grown as often as possible on the land.

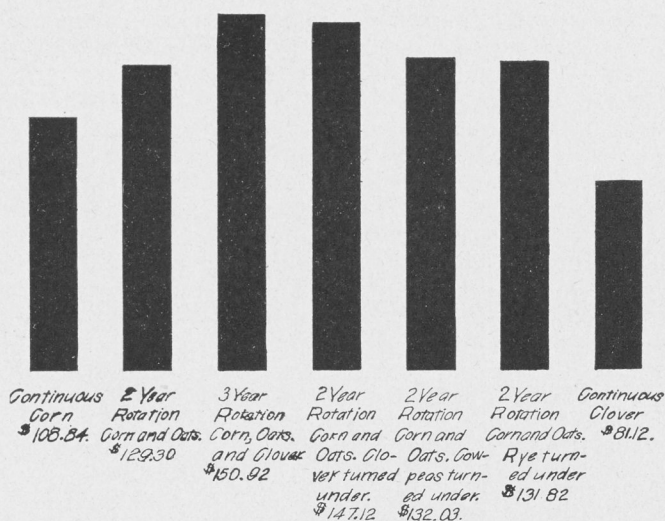


FIG. 2. The columns show the total average value of yields of crops in various rotations, six years, 1908 to 1913

Also, the introduction of green manure crops into the two-year rotation increases the value of the crops grown over the unmodified rotation, the clover showing a considerable effect, while the cowpeas and the rye give only a very slight effect. Just why this should be the case is difficult to determine. It may be due to a greater amount of nitrogen being supplied to the soil in the clover crop, but in that case it would be expected that the cowpeas would be quite as valuable as the clover. It may be due, of course, to some other factor about which we know little at the present time; such, for instance, as the chemical composition of the crop used. The lower yields of corn in the two-year rotation with rye turned under than where the clover or cowpeas were used may be attributed partly to the fact that the crops of rye were so much larger in every case and that turning this under in the soil affected moisture conditions undesirably, and partly to the fact that no nitrogen was added to the soil in this crop.

Considering the cost of seeding these crops in the two-year rotation, it is clear that the use of the cowpeas or the rye would be unprofitable. In the case of the clover however, its use in the rotation brought about a large enough increase in crops to make it profitable. In general, the use of such green manure crops in the two-year rotation should be considered as unprofitable and the employment of a three-year rotation or some other rotation containing clover as a regular crop should be regarded as preferable.

These results as a whole serve to emphasize the fact that the



continuous growing of corn not only leads to a depletion in the fertility of the soil but also is less profitable than the use of rotations. They prove, also, the fallacy of the idea that corn should be grown as often as possible on the soil, for the three-year rotation is found more profitable than the two-year rotation. Furthermore, the tests show that it is better to grow clover regularly in the rotation than to introduce it as a green manure.

It must be emphasized here again that these results represent only six years of work and hence should not be interpreted too broadly. Longer continued tests might have modified the results somewhat, but the greater value of a rotation over continuous cropping is clearly shown and the greater value of a three over a two-year rotation also appears definitely.

### THE EXPERIMENTS WITH MANURE

The manure experiments were planned to study the effects of using various amounts of manure and to determine the best methods of application, whether the full amount should be applied at one time in the four-year rotation, or divided into three equal applications; and also whether the manure in one application should be applied before plowing and plowed in, disced in after plowing, or cultivated in after the corn crop is up.

#### THE AMOUNT OF MANURE TO APPLY

The experiment to study the amount of manure to apply was carried out on 20 plots, 1/10 acre in size, and 2 rods wide by 8 rods long; the division strips were 6½ feet wide and a cropped border 6½ feet wide extended around the plots. The topography of the area was quite uniform and the drainage adequate.

The treatments followed in the experiment were as follows:

Check.

8 tons of manure per acre.

12 tons of manure per acre.

16 tons of manure per acre.

20 tons of manure per acre.

The plan of the experiment is shown in fig. 3. There were four series of plots each under the above treatments and they were cropped to a four-year rotation of corn, corn, oats, and clover. Thus each year every crop of the rotation was represented on one series of plots.

The experiment was begun in 1907, the manure being applied to one series of the plots (904-908) in the fall of that year preceding the first corn crop of the rotation. The yields for that series of plots were secured, therefore, for five years, or until 1913. On the second series (909-913), the manure was applied in the fall of 1908 on the clover crop and the yields on that series

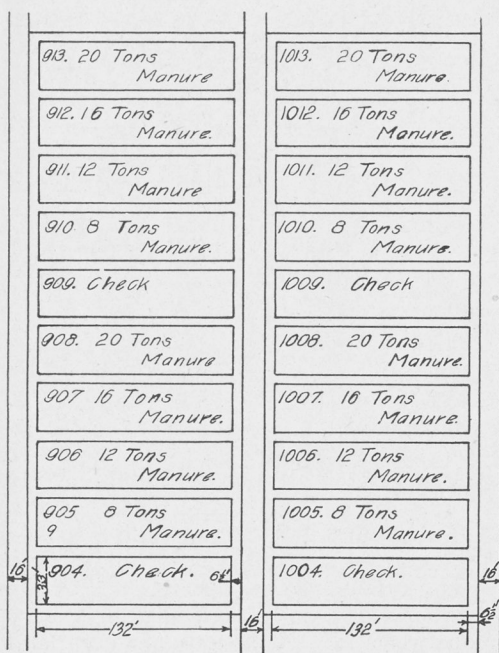


FIG. 3. Manure experiment, 4 year rotation, 1-10 acre plots

were obtained for only four years. On the third series of plots (1004-1008), the manure was applied in the fall of 1910 on the clover and hence yields for only two years were secured. On the fourth series of plots (1009-1013), the application of manure occurred in the fall of 1909 and three years' results were obtained in that case.

The average yields for the corn and oats crops were figured from the yields secured on the four series of plots, following the application of manure or, as has been pointed out, for five, four,

three, and two years. The total average, therefore, for the corn is based on nine crops and that for the oats on three crops.

The clover in the second series of plots was a failure in 1912 and the yield was not secured, and in the third and fourth series the clover crop in the rotation was not reached and hence the yield in 1911 on the first series of plots was the only one available. The clover yields, therefore, cannot be included in the results of the tests.

The average yields of corn and oats and the increases for the application of manure over the untreated soils were calculated and the results appear in table II.

The manure increased the yields both of the corn and of the oats. In the case of the corn, the 12 ton application gave the largest increase and the 16 ton amount showed a slightly smaller gain. When the 20 tons of manure were applied, however, the increase in yield was very much less than with the other applications. Evidently, the best effects from the use of manure may be secured on this soil by the application of between 12 and 16 tons per acre. Just why the 20 ton amount should give a lower yield than the smaller applications can hardly be determined. It may be due to the larger amount of organic matter supplied,



TABLE II. AVERAGE YIELDS OF CORN AND OATS ON FOUR SERIES OF PLOTS IN A FOUR YEAR ROTATION<sup>1</sup>—MANURE APPLIED ONCE IN ROTATION—FIVE YEARS<sup>2</sup>—1908-1912

Treatment	Corn Bu.	Increase Bu.	Oats Bu.	Increase Bu.
Check .....	63.46	.....	66.83	.....
8 tons Manure.....	71.46	8.00	70.80	4.03
12 tons Manure.....	72.26	8.80	71.00	4.17
16 tons Manure.....	72.01	8.55	74.21	7.38
20 tons Manure.....	69.50	6.04	71.21	4.38

<sup>1</sup> Clover yields not secured.<sup>2</sup> Average yield secured on all four series of plots only following application of manure thus:

Series A (904-908) — 1908-1912 — 5 years.

Series B (909-913) — 1909-1912 — 4 years.

Series C (1004-1008) — 1911-1912 — 2 years.

Series D (1009-1013) — 1910-1912 — 3 years.

to the development of acid conditions in the soil, or to other factors not determinable.

When the oats yields are examined it is found that the 16 ton amount of manure gave the largest increase in yield, the other amounts showing smaller gains which are not very different for the various applications. The 20 ton application again gave a lower yield than the 16 ton amount, but the increase over the check was greater than that secured with the 8 or 12 ton applications. This is the direct opposite of the results obtained in the case of the corn. It seems here that the best amount of manure to apply was somewhere between 12 and 20 tons per acre, and hence the results check fairly satisfactorily those secured with corn. In that case the best effect appears to be secured between 12 and 16 tons and it is quite possible that the same is true in the case of the oats.

The effect of the manure was less pronounced on the oats than on the corn, about 8 bushels increase being secured with the latter crop and only 4 to 7 bushels with the former.

The results with the oats and the corn are shown graphically in fig. 4.

In general these results show that it is inadvisable to apply a very large amount of manure to the Carrington loam. From 8 to 16 tons per acre seems to be the best amount. Adding more than this reduced considerably the yield of corn and to a less extent also the yield of oats. In neither case, however, was the reduction sufficient to make the yields less than those of the untreated soils. Larger applications of manure might reduce the yields still further and in such a case the applications might actually prove injurious. It is apparent, therefore, that in the use of manure on this soil it should not be assumed that if a little is good a large amount would be better.

In ordinary farm practice the manure produced is usually sufficient to meet the needs of the soil so that it is hardly likely that too large an amount would be applied, but it is well to em-

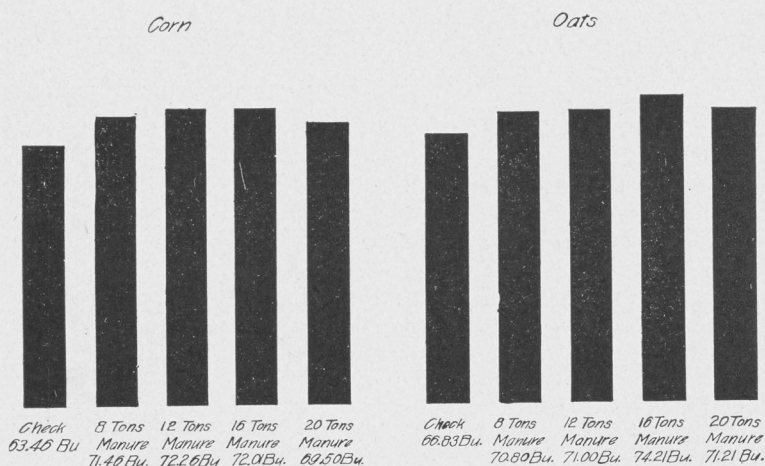


FIG. 4. The columns show the average yields of corn and oats in the manure experiment, 5 years, 1908 to 1912

phasize the fact that manure should be distributed as uniformly as possible over the farm and not applied largely to one part on the assumption that such an application will prove profitable.

Of course this work dealt only with ordinary farm crops and the conclusions should be considered applicable only under general farming conditions. Where market gardening or truck farming is practiced, much larger applications of manure may be made with safety. This is due to the fact that such systems of farming are usually followed on rather light soils, poor in organic matter, and also to the fact that truck crops frequently require some forcing and the manure stimulates their growth.

Under ordinary farming conditions, however, there is evidently little value attached to the use of very large amounts of manure and there is danger of an actual injury being brought about if excessive quantities are used.

#### THE TIME IN THE ROTATION TO APPLY MANURE

This experiment was carried out on 8 plots 1/10 acre in size on land rather uniform in topography and well drained. The plan of the experiment is shown in fig. 5. The plots were 2 rods wide by 8 rods long and were separated by 6 1/2 foot division strips as usual. They were also surrounded by a cropped border 6 1/2 feet in width.

Four plots were treated with manure at the rate of 9 tons per acre once in the four-year rotation of corn, corn, oats, and clover. The other four plots received applications of 3 tons of manure in the first, second, and fourth years of the four-year rotation. Thus, the manure was applied in the latter case on each of the

corn crops and on the clover. On the plots receiving the 9 ton amount once in the rotation, the application was made in different years, to plot 705 in 1910, to 706 in 1908, to 707 in 1908, and to 708 in 1909.

The experiment was begun in 1908 and continued until 1913, hence six yields were secured on some of the plots. The yields were not taken on any of the plots until after the manure had been applied, so that there is some variation in the number of crops averaged in from the various plots. The yields on plots 701 and 702 were secured for six years, for 703 for five years, and for 704 for four years. For plot 705 the yield for only three years was obtained, for 706 for six years, for 707 for five years, and for 708 for four years. According to the plan of the experiment, there were provided four plots under each treatment so that each crop of the four-year rotation was represented each season and hence variations in crops due to seasonal influences were very largely eliminated.

The average yields of corn, oats, and clover under the two methods of treatment have been calculated and the results appear in table III.

The average yield of corn in the case of the three applications of manure in the rotation is based on 12 crops secured in the six years and in the case of the one application it is based on 11 crops obtained in the six years and so the results should be quite comparable. The average oats yields are based on five crops and on four crops respectively for the three applications and the single application so that here too comparisons should be satisfactory. In the case of the clover crop there were so many failures to secure a stand of the clover, in which case cowpeas were grown and the yields not recorded, that only two crops have been averaged for each treatment. The results with the clover should not be considered of much weight, but they are included as they apparently bear out the results secured with the corn and oats.

Examining the results given in table III it appears that the application of the manure in three proportionate amounts in the first, second, and fourth years of the rotation gave a larger yield of corn, of oats, and of clover than the application of the same total amount once in the four years. The differences were not large, but in the case of the corn there was an increase of about

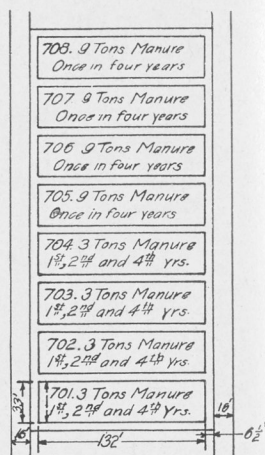


FIG. 5. One manuring vs. three in 4 years, 1-10 acre plots

TABLE III. AVERAGE YIELDS<sup>1</sup> OF CORN, OATS AND CLOVER IN FOUR YEAR ROTATION WITH MANURE APPLIED IN DIFFERENT WAYS—SIX YEARS—1908-1913

Treatment	Corn Bu.	Oats Bu.	Clover Tons
Manure applied at rate of 3 T. per acre, 1st, 2nd and 4th years of rotation.....	67.03	57.18	2.32 <sup>2</sup>
Manure applied at rate of 9 T. per acre once in Rotation .....	64.60	55.80	2.19 <sup>3</sup>

<sup>1</sup> Average yields secured on all series of plots following application of manure thus:

Plot 701—1908-1913—6 years.  
 702—1908-1913—6 years.  
 703—1909-1913—5 years.  
 704—1910-1913—4 years.  
 705—1911-1913—3 years.  
 706—1908-1913—6 years.  
 707—1909-1913—5 years.  
 708—1910-1913—4 years.

<sup>2</sup> Only two clover crops secured in entire series—the crop failed several times.<sup>3</sup> Only two clover crops secured in entire series.

21½ bushels per acre for the three applications over the one, and with the oats the increase amounted to about 1½ bushels per acre. Fig. 6 shows the relative yields of corn, oats, and clover.

It is apparent from these results that on the Carrington loam, in order to secure larger crops, it is advisable to apply manure three times in equal amounts during the four-year rotation rather than to make only one application every four years, even altho the same amounts be applied in both cases in the four-year period. It is probable that this better effect of the three applications over the one is due to the fact that the bacterial processes

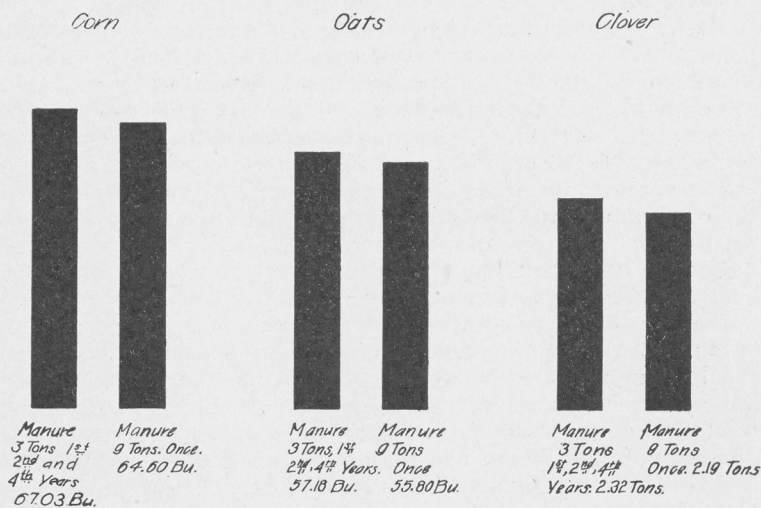


FIG. 6. The columns show the average yields of crops in 4 year rotation, manure applied in various ways, 6 years, 1908 to 1913



in the soil and the physical condition of the soil are kept more nearly at the best by several small additions of manure. The beneficial effects of manure are known to be due mainly to the improved physical conditions in the soil and to the increased transformation of insoluble plant food into available form through bacterial agency. Manure introduces large numbers of bacteria into the soil and also increases the activity of organisms already present, thus causing the production of a larger amount of available plant food. It appears that the smaller applications of manure are sufficient to encourage an adequate production of available plant food and when the same total amount of manure is added in one application, the production of soluble plant food is not encouraged to so large an extent, or at least the increased action does not persist for the four years of the rotation, or until the next application of manure is made.

It is quite possible that these results are applicable only to the Carrington loam, for as has been mentioned, this soil is rather rich in plant food and also in organic matter and the conditions in other soils might be so different that the heavy application of manure once in the rotation would prove preferable.

#### THE APPLICATION OF MANURE IN VARIOUS WAYS

A test was also made of the relative value of different methods of applying manure to the soil. Thirteen plots were laid out,  $1/20$  of an acre in size, 2 rods wide by 4 rods long, separated by division strips  $6\frac{1}{2}$  feet wide and surrounded by a cropped border  $6\frac{1}{2}$  feet in width as usual. The plan of the experiment is given in fig. 7. There were three series of plots and four plots in each series. A three-year rotation of corn, oats, and clover was followed on the plots. Thus there was provided each year one series of plots including all the treatments studied under each crop of the rotation. There was an extra check plot which is averaged with the others, making a total of four check plots.

The manure was applied at the rate of 6 tons per acre once in the rotation and the methods of application were as follows:

Check.

Manure plowed under.

Manure disced in after plowing.

Manure cultivated in after corn was up.

The experiment was begun in 1908 and the manure was applied to one series of plots (801-804) in that year. The second series (805-808) received the application of manure in 1909 and the third series (809-813) in 1910. In 1912 the experiment was discontinued and there are therefore provided crop yields for five years on the first series, for four years on the second series, and for three years on the third series of plots.

The average yields of corn, of oats and of clover and the in-

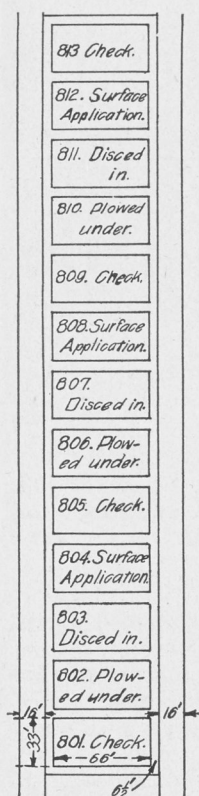


FIG. 7. Manuring in various ways, 3 year rotation, 1-20 acre plots

creases for the various manure treatments over the untreated plots are recorded in table IV. The average yields of corn are based on five crops, those for oats on four crops and the clover yields are those secured on one series of plots in 1911. In all other cases the clover was a failure and the cowpeas were grown and the yields of this crop were not secured. Little significance can be attached to the clover yields, therefore, but they are included as they check quite satisfactorily the results obtained with the corn and oats crops.

Examining the average results given in table IV, it appears that the use of manure, however it was applied, increased considerably the yields of corn, of oats, and of clover. The greatest increase in every case was brought about by discing in the manure after plowing. The difference was not much larger, however, than that shown when the manure was plowed under. When the manure was cultivated in after the corn was up the increase in yield was very much smaller than when the application was made in any other way. This was the case with the corn, the oats and the clover. The average yields of the three crops are shown in fig. 8.

It is evident from these results that the manure applied to this soil gave the greatest effect when disced in after plowing, an effect slightly larger than that secured when the manure was plowed under. When the manure was cultivated in after the corn crop was up, the value for the

TABLE IV. AVERAGE YIELDS<sup>1</sup> OF CROPS IN THREE YEAR ROTATIONS — MANURE APPLIED IN VARIOUS WAYS ONCE IN THREE YEARS — FIVE YEARS — 1908-1912

Treatment	Corn Bu.	Increase Bu.	Oats Bu.	Increase Bu.	Clover <sup>2</sup> Tons	Increase Tons
Check .....	57.16	.....	60.54	.....	2.43	.....
6 T. Manure plowed under...	63.53	6.37	65.62	5.08	2.84	0.41
6 T. Manure disced in after plowing .....	64.29	7.13	65.89	5.35	2.90	0.47
6 T. Manure cultivated in after corn up .....	60.20	3.06	61.56	1.02	2.76	0.33

1. Clover yield secured only on one series of plots (805-808) in 1911. In all other years the clover was a failure.

2. Average yields secured for corn and oats on all three series of plots following applications of manure thus:

Series A (801-804) — 1908-1912 — 5 years.

Series B (805-808) — 1909-1912 — 4 years.

Series C (809-813) — 1910-1912 — 3 years.



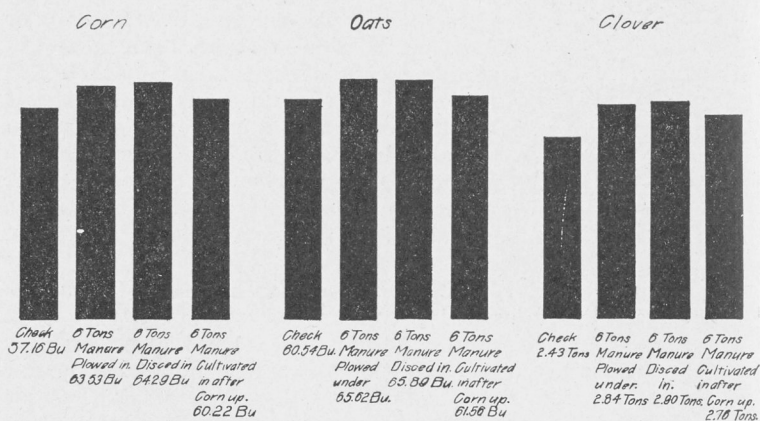


Fig. 8. The columns show the average yield of crops in 3 year rotation, manure applied in various ways, 5 years, 1908 to 1912

application is shown very definitely to be very much reduced.

It might be expected that the cultivation in of manure after growth of the corn had started would be of less value than to plow or disc it under, for by the latter methods time is allowed for some decomposition of the manure, and the best effects may thereby be secured. When it is cultivated in, the decomposition processes are considerably delayed and while some effects are secured on the later growth of the crop, the early growth is not influenced and hence the complete effect of the application is less pronounced.

Just why discing in the manure should prove of more value than plowing it under is rather difficult to determine. It is probable, however, that greater effects on the decomposition processes are brought about near the surface by the discing method and hence the influence on the young plants is greater. In some instances the effects on the moisture conditions would be of importance but they could hardly be considered so in the case of this soil. On other soils, it is quite possible that plowing under the manure would be more valuable. This method is the one which is recommended for most soils under general farming conditions as in that way the manure is incorporated with a larger amount of soil and the decomposition processes in the soil are more generally encouraged to the benefit of the crop at all stages of growth. Then too the maximum effects on the physical conditions of the soil are secured.

In a general way it may be concluded from these experiments that manure should not be applied to this soil and cultivated in after the corn is up. The best method is to plow it under or to disc it in after the land is plowed.

# Index for Bulletins Numbers 155-167 Volume 14

## A

Alkali soils in Iowa .....	43, 72
Cause of .....	74
Composition of .....	75
Indications of .....	72
Location and extent of .....	43, 72
Origin of .....	72
Treatment of .....	75
Ash fence posts .....	130
Condition of creosoted posts after 9½ years' service .....	134
Condition of butt treated posts after 9½ years' service ....	132
Length of service of creosoted posts .....	132
Saving in creosoting .....	135
Treatment of .....	130

## B

Bacteriological studies of cream .....	27
Factors affecting bacterial count .....	28
Influence of pasteurization on keeping qualities of butter..	33
Results obtained .....	29
Basswood fence posts .....	138
Treatment of .....	138
Bichloride of mercury, see Corrosive sublimate	
Black walnut fence posts .....	137
Creosote absorbed .....	137
Treatment of .....	137
Blight, on potatoes in Iowa .....	287
Blue vitriol, see Copper sulphate	
Boxelder fence posts .....	135
Condition of butt treated posts after 9½ years' service ....	136
Length of service of creosoted posts .....	137
Treatment of .....	135
Brown, P. E., joint author "Improving Iowa's peat and alkali soils" .....	43
Joint author, "Maintaining fertility in the Wisconsin drift soil area in Iowa" .....	235
Joint author "Rotation and manure experiments on the Wisconsin drift soil area" .....	463
Brush method of treating fence posts with preservatives.....	105
Butter from pasteurized cream .....	4
Butternut fence posts .....	139
Creosote absorbed .....	139

C

Carrington loam .....	462, 236
Community hog houses, article by J. B. Davidson, John M. Evvard and W. G. Kaiser .....	407
Advantages .....	409
Disadvantages .....	415
Essentials of an ideal hog house .....	408
Frame construction of Iowa sunlit community hog house..	448
Bill of materials and estimate of cost.....	448
Half monitor type of hog house .....	454
Bill of materials and estimate of cost .....	456
Iowa sunlit community hog house .....	423
Advantages .....	423
Cost .....	428
Masonry construction of Iowa sunlit community hog house	429
Advantages .....	429
Bill of materials and estimate of cost .....	446
Plan .....	430
Three-row pen Iowa sunlit community hog house.....	451
Bill of materials and estimate of cost .....	451
Types .....	422
Cooper, W. H., joint author "Pasteurization of cream for butter- making" .....	3
Copper sulphate (Blue vitriol) as a wood preservative.....	88
Corrosive sublimate (Bichloride of mercury) as a wood preservative .....	88
Cottonwood fence posts .....	124
Condition of creosoted posts after 9½ years' service.....	129
Condition of butt treated posts after 9½ years' service.....	127
Cresote absorbed .....	125
Length of service of creosoted posts .....	126
Saving in creosoting .....	130
Treatment of .....	125
Cream, Aeration of after pasteurization .....	11
Bacteriological studies of .....	27
Pasteurization of for buttermaking .....	3
Creosote, for treating fence posts .....	88
Amount absorbed by ash posts .....	131
Amount absorbed by cottonwood posts .....	125
Amount absorbed by soft maple posts .....	120
Amount absorbed by willow posts .....	112
Amount absorbed by white cedar posts .....	141
Coal tar creosotes .....	89
Cost of .....	90
Results of distilling .....	90
Testing for penetration .....	109
Use in open tank work .....	89
Crops, rotation of, on Wisconsin drift soil area.....	464
Selection of, for Iowa peat soils .....	70

## D

Dairy production, influence of environment and breeding in	
increasing .....	383
Comparisons of scrub cows to daughters by pure bred sires	394
Increase in profit .....	395
Percentage increase in butterfat .....	395
Digestive and feeding ability of scrub and grade calves....	398
Digestion of feed by calves .....	401
Feed consumption and gains .....	401
Investigations .....	385
Animals used .....	385
Objects of .....	385
Plan of .....	386
Results of .....	387
Number of dairy cows in the United States .....	383
Successive lactation periods of scrub cows .....	387
Average yearly records .....	387
Difference in yields and returns .....	389
Davidson, J. B., joint author "Community hog houses".....	407
Dipping method of treating fence posts with preservatives .....	105
Division of returns between landowner and tenant .....	165
Drainage of peat soils .....	67
Of alkali soils .....	75

## E

<i>Empria Fragariae</i> Rohwer (Early strawberry slug) .....	270
Adult, description of .....	277
Classification of .....	271
Egg, deposition and maturity .....	272
History of .....	270
Generations in Iowa .....	271
Larva, where found and nature of cocoons .....	274
Natural enemies .....	278
<i>Empria Maculata</i> Norton (Late strawberry slug).....	278
Adult, description of .....	282
Classification of .....	279
Egg, deposition and maturity .....	279
Generations in Iowa .....	270
Larva, where found and nature of cocoons .....	280
Equipment, for treating fence posts .....	97
Expense .....	98
Home made outfit .....	103
Installation .....	98
Location and arrangement .....	104
Evvard, John M., joint author "Community hog houses".....	407
Erwin, A. T., author "Late potato blight in Iowa".....	287
European larch fence posts .....	138

F

Farm leases in Iowa, article by O. G. Lloyd .....	157
Definitions of terms used .....	158
Essentials of satisfactory lease .....	158
Fair division of returns .....	165
Profitable farming .....	159
Fair division of farm income .....	184
Methods of renting .....	174
Bushel renting .....	178
Cash renting .....	176
Share-cash renting .....	177
Stock-share renting .....	175
What determines choice of .....	204
Provisions of a satisfactory lease .....	191
Cropping system that will maintain crop yields .....	192
Fair division of returns .....	194
Indemnity for inefficient use .....	194
Promise of long tenure .....	192
Proper amounts of labor and capital which should be used .....	192
Reward for unexhausted improvements .....	193
Relation of methods of renting and profitable farming .....	178
Equipment and supervision .....	182
Live stock farming and yield of corn .....	179
Size of business .....	178
Years of occupancy .....	180
Satisfactory leases of a satisfactory method of renting .....	186
Conservative stock share lease .....	186
Liberal stock share lease .....	186
Typical successful stock-share rented farms .....	195
Beef cattle farm .....	197
Dairy and hog farm .....	199
General farm .....	202
General live stock farm .....	195
Hog farm .....	201
Farming, types of .....	195
Ownership vs. tenancy .....	170
Fence posts .....	85
Annual cost of .....	85, 146, 150
Average life of Iowa fence post woods .....	149
Decay of .....	85
Decay, Prevention of .....	87
Factors influencing durability .....	86
Kinds of wood and treatment .....	110, 148
Ash .....	130
Basswood .....	138
Boxelder .....	135
Black walnut .....	137
Butternut .....	139



Cottonwood .....	124
European larch .....	138
Soft maple .....	119
White cedar .....	139
White elm .....	138
Willow .....	110
Preparation for treatment .....	92
Cutting .....	92
Methods of piling .....	93, 94
Peeling .....	92
Seasoning .....	92
Preservative treatment of .....	85, 97
Brush method .....	105
Cost of .....	109
Dipping method .....	105
Equipment for treatment on farm.....	97
Necessity for .....	85
Open tank method .....	105
Selection of species for .....	151
Single tank method .....	105
Size of posts treated .....	97
Split or round posts .....	95
Top treatment of undurable woods .....	106
Two tank method of treatment.....	106
Fertilizers for Wisconsin drift soil area .....	235
Effect of on peats .....	54, 70
Effect of on alkali .....	76
Influence of on yield .....	56
Legume crop (cowpeas) .....	240
Limestone .....	261
Manures .....	257
Phosphorus .....	259
Potassium .....	260
Forewarmer, in pasteurization .....	9
Forman, L. W., joint author "Maintaining fertility in the Wisconsin drift soil area in Iowa" .....	235

# G

Gaessler, W. G., joint author, "Pasteurization of cream for buttermaking" .....	3
Grape pruning .....	211
Bibliography of .....	231
Experiments with .....	213
Dorland vineyard (Council Bluffs) .....	214
Johnson vineyard (Council Bluffs) .....	216
Konigmacher vineyard (Council Bluffs) .....	217
Rich vineyard (Council Bluffs) .....	215
Old vines .....	218
Relation of to insect control .....	231



Second year pruning .....	226
Selection of fruiting canes .....	223
Spur and Long cane systems compared, article by T. J. Maney .....	211
Third year pruning to determine type .....	226
Tools for pruning, cost of .....	228
Time for .....	224
Trellis for canes .....	226
Tying up pruned vines .....	230
Gypsum, effect on Iowa peat .....	77

## H

Hammer, B. W., author "Bacteriological studies" .....	27
Joint author "Studies on the market milk of Iowa" .....	311
Hauser, A. J., joint author "Studies on the market milk of Iowa" .....	311
Hog houses, community, see Community hog houses	

## I

Improving Iowa's peat and alkali soils, article by W. H. Stevenson and P. E. Brown .....	43
Income, farm .....	159
Income, labor .....	159
Influence of environment and breeding in increasing dairy production, article by H. H. Kildee and A. C. McCandlish .....	383
Insect pests .....	267
Strawberry slugs .....	267
Control measures .....	269
Time of appearance in Iowa .....	269
Iowa sunlit community hog house .....	423

## K

Kaiser, W. G., joint author "Community hog houses" .....	407
Kildee, H. H., joint author "Influence of environment and breeding in increasing dairy production" .....	383

## L

Late potato blight in Iowa, article by A. T. Erwin.....	286
Lead arsenate as a spray for strawberry slug .....	269
Leases, farm, see Farm leases	
Limestone, effect on Iowa peat .....	77
Use and value of on Wisconsin drift .....	261
Lloyd, O. G., author "Farm leases in Iowa" .....	157

## M

McCandlish, A. C., joint author "Influence of environment and breeding in increasing dairy production".....	383
MacDonald, G. B., author "Preservative treatment of fence posts" .....	85
Maintaining fertility on the Wisconsin drift soil area in Iowa, article by W. H. Stephenson, P. E. Brown and L. W. Forman .....	235

Maney, T. S., author "Comparison of spur and long cane systems in grape pruning" .....	211
Manures, amount to apply .....	468
Application of in various ways .....	474
Effect of on Iowa peat.....	97
Effect of on Wisconsin drift .....	257, 468
Time in rotation to apply .....	471
Market milk of Iowa .....	311
Buttermilk, artificial and churned .....	348
Prevailing prices .....	348
Delivery of milk .....	350
Judging value of milk and cream .....	313
Milk legislation .....	312
Results of study of in Iowa cities .....	317, 357
Algona .....	317, 358
Ames .....	320, 359
Boone .....	322, 361
Cedar Rapids .....	324, 362
Clinton .....	327, 364
Council Bluffs .....	329, 367
Des Moines .....	332, 369
Fort Dodge .....	334, 371
Marshalltown .....	337, 373
Nevada .....	339, 375
Newton .....	342, 375
Webster City .....	344, 377
Results on colon bacteria .....	349
Volume of milk present in bottles of various sizes .....	351
Whipping cream .....	347
Mortensen, M., joint author "Pasteurization of cream for butter- making" .....	3

## O

Open tank method of treating fence posts with preservatives...	105
Ownership vs. tenancy of farm lands .....	170

## P

Pasteurization of cream for buttermaking, article by M. Mor- tensen, W. G. Gaessler, W. H. Cooper and B. W Hammer .....	3
Influence of different methods of pasteurization on chemical composition of butter .....	12
Influence on keeping qualities of butter .....	33
Loss of fat .....	14
Sour cream .....	5
Aeration of cream .....	11
Continuous pasteurization .....	6
Continuous pasteurization compared with continuous method, using a forewarmer .....	9

Vat pasteurization .....	7
Vat pasteurization compared with continuous method, using a forewarmer .....	10
Sweet cream .....	3
Vat pasteurization .....	3
Table showing results of experiments with methods of pasteurization .....	16
Peat soils in Iowa .....	44
Analysis of .....	50
Classes of .....	46
Composition of .....	49
Fields tests .....	53
Eagle Grove .....	60
Ontario (1905) .....	62
Ontario (1906) .....	65
Somers (1905) .....	53
Somers (1906) .....	57
Location and extent of .....	43
Methods of treatment .....	67
Drainage .....	67
Preparation for crops .....	67
Selection of crops for .....	68
Phosphorus, effect on Iowa peat .....	77
Use and value of on Wisconsin drift .....	260
Potassium, effect on Iowa peat .....	77
Use and value of on Wisconsin drift .....	260
Potato blight in Iowa .....	287
Control methods .....	
Clean seed .....	296
Spraying .....	305
Disease resistant varieties .....	295
Field observations .....	288
Humidity during outbreaks .....	290
Rainfall during outbreaks .....	288
Relation of moisture to outbreaks .....	288
Relation of temperature to outbreaks .....	291
Temperature during outbreaks .....	292
Home grown vs. imported seed .....	297
Nature and extent of .....	287
Outbreak of .....	293
Seed infection of .....	296
Storage qualities of infected potatoes .....	298
As affected by time of digging .....	303
As affected by time of planting .....	301
Preservative treatment of fence posts, article by G. B. MacDonald .....	85
Preservatives, of wood fence posts .....	88
Profitable farming .....	171

## R

Rotation and manure experiments on the Wisconsin drift soil area, article by W. H. Stevenson and P. E. Brown.....	463
Rotation of crops, on Wisconsin drift.....	251, 463
Single tank method of treating fence posts with preservatives..	105
Soft maple fence posts .....	119
Condition of butt treated posts after 9½ years.....	122
Condition of creosoted posts after 9½ years.....	122
Length of service of creosoted posts .....	121
Creosote absorbed .....	120
Saving in creosoting.....	124
Treatment of .....	119
Speculation and farm tenancy.....	167
Stevenson, W. H., joint author "Improving Iowa's peat and alkali soils" .....	43
Stevenson, W. H., Joint author "Maintaining fertility in the Wisconsin drift soil area in Iowa.....	235
Stevenson, W. H., Joint author "Rotation and manure experiments in the Wisconsin drift soil area".....	463
Strawberry slugs in Iowa .....	267
Appearance and extent of damage.....	267
Control measures .....	269
Cultivation .....	269
Rotation .....	269
Spraying for early slug .....	269
Spraying for late slug.....	270
Kinds .....	270
<i>Empria Fragariae</i> Rohwer (Early strawberry slug)....	270
<i>Empria Maculata</i> Norton (Late strawberry slug) ....	278
Time of appearance.....	288
Studies on the market milk of Iowa, article by B. W. Hammer and A. S. Hauser.....	311
Tenancy vs. farm ownership.....	170
Two strawberry slugs, article by R. L. Webster.....	267
Two tank method of treating fence posts with preservatives....	193

## W

Webster, R. L., author "Two strawberry slugs".....	267
Wisconsin drift soil area.....	235, 463
Cultivation .....	261
Drainage .....	261
Experiments .....	237
With clover .....	248
With continuous corn.....	252
With corn .....	241
With oats .....	245
Green manuring .....	240, 258
Liming .....	261

Location of .....	236
Manuring .....	257, 468
Plant food content of .....	236
Phosphorus, use of .....	240, 259
Potassium, use of.....	240, 260
Recommendations for handling.....	255
Rotation of crops.....	251, 256, 464
Soil type .....	236
White cedar fence posts .....	139
Creosote absorbed .....	141
Length of service of creosoted posts.....	142
Treatment of .....	142
White elm fence posts.....	138
Creosote absorbed .....	138
Willow fence posts .....	110
Comparison of annual costs in treated and untreated posts..	119
Condition of butt treated posts after 7½ years' service....	113
Condition of butt treated posts after 9½ years' service....	115
Condition of creosoted posts after 9½ years' service.....	118
Durability of untreated posts.....	110
Length of service of creosoted posts.....	112
Treatment of .....	112
Wood preservatives .....	88
Zinc arsenite as a spray for strawberry slug.....	269
Zinc chloride as a wood preservative.....	88